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ABSTRACT

In this exploratory study, researchers compared characteristics and teaching practices of teachers, perceived by themselves to be exemplary technology-users, with characteristics and teaching practices of exemplary users described in the literature. Using a qualitative case-study design, the researchers examined the pedagogical beliefs and classroom practices of 17 exemplary technology-using teachers. After gathering open-ended questionnaire, interview, and observation data, they analyzed the beliefs and practices that were common and distinct across teachers. Findings suggest that exemplary technology use, as perceived and practiced by teachers, did not readily match descriptions of best practice provided in the literature. Rather, exemplary use reflected teachers' personal beliefs about teaching and learning as well as their specific teaching contexts. In this study, technology best practices differed in relationship to the grade level at which teachers worked, the visions they embraced, and the very real constraints under which teachers attempted to implement their visions, in terms of both curricular expectations and available resources. (Contains 40 references.) (Author/SM)

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Technology-Using Teachers:

Comparing perceptions of exemplary technology use to best practice

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Abstract

In this exploratory study we compared characteristics and teaching practices of teachers, perceived by themselves to be exemplary technology-users, with characteristics and teaching practices of exemplary users described in the literature. Using a qualitative case-study design we examined the pedagogical beliefs and classroom practices of seventeen exemplary technology-using teachers. After gathering open-ended questionnaire, interview, and observation data, we analyzed the beliefs and practices that were common and distinct across teachers. Findings suggest that exemplary technology use, as perceived and practiced by teachers, did not readily match descriptions of best practice provided in the literature. Rather, exemplary use reflected teachers' personal beliefs about teaching and learning as well as their specific teaching contexts. In this study, technology best practices differed in relationship to the grade level at which teachers worked, the visions they embraced, as well as the very real constraints under which teachers attempted to implement their visions, in terms of both curricular expectations and available resources.

Educators today are confronted with a number of alternative, often opposing, views of what technology is and the purposes it should serve within instructional settings. Although studies have shown that most teachers today recognize the importance of using technology in their classrooms (Beichner, 1993; Fulton, 1993), they often lack a clear vision of how technology can be used to support educational best practices (Roblyer, 1993). Not only do the tools, themselves, continue to change at a rapid pace, but so does the prevailing wisdom on how teachers should use these technologies in schools—from teaching programming, to encouraging individualized drill and practice, to building computer literacy, to participating in electronic communities (OTA, 1995). Given the evolving nature of technology best practice, it is quite possible that today's practitioners and researchers have very different beliefs about what constitutes exemplary classroom technology use. Based on the assumption that teachers behave in concert with their beliefs (Erickson, 1986), this study was designed to examine the pedagogical beliefs and classroom practices of exemplary technology-using teachers and to determine the extent to which their beliefs corresponded with educational best practice, as described in the literature.

According to Dexter, Anderson, and Becker (1999): "The research on technology-using teachers characterizes different ways teachers employ technology in instruction. Data from this literature suggest that technology-using teachers range along a continuum of instructional styles from instruction to construction" (p. 221). Becker and Riel (1999) noted that teachers at the instruction end of the continuum "define teaching as a process of successful implementation of a set of frameworks or standards established by others" (p. 4). In contrast, teachers at the construction end define teaching as "a process of continual, reflective inquiry" (p. 4). The President's Panel on Educational Technology (1997) noted that constructivist teachers place "the locus of initiative and control largely within the student, who typically undertakes substantial, authentic tasks, presented in a realistic context, that require the self-directed application of various sorts of knowledge and skills for their successful execution" (p. 34).

Although we can find examples of technology-using teachers who fall at every point along this instruction-construction continuum, the literature on exemplary technology use seems to suggest

that expert technology-using teachers (do or should) reside on the far right (the constructivist) side of the continuum (Becker, 1994; Dede, 1998; Dexter et al., 1999; Jonassen, Peck & Wilson, 1998; President's Panel on Educational Technology, 1997). Recent literature on classroom practice, in general (Brown, 1997; Bruer, 1994; Cognition and Technology Group at Vanderbilt, 1997; Walberg & Haertel, 1997), and technology use within that practice (Becker; 1994; Berg, Benz, Lasley, & Raisch, 1998; Hadley & Sheingold, 1993), has tended to define "exemplary" in terms of the extent to which teachers' practices embrace a constructivist teaching philosophy. For example, the President's Panel on Educational Technology (1997) stated:

> While the Panel is unable to make a confident and definitive statement regarding the superiority of the constructivist approach, it believes there to be a high likelihood that many or all of the essential elements of this approach could play a major role in improving the quality of our nations' elementary and secondary schools. Although technology is likely to find use within a number of more traditional instructional roles as well, it seems likely (though not yet certain) that the student-centered constructivist paradigm may ultimately offer the most fertile ground for the application of technology to education (p. 35; emphasis in original).

Grabe and Grabe (1996) and others (Hooper & Rieber, 1995; Jonassen, Peck, & Wilson, 1999) have outlined the primary differences between traditional and constructivist classroom environments (see Table 1). In general, the literature on technology-using teachers describes exemplary use as that which supports the type of activities and approaches noted on the right side of the table. Thus, technology best practice would incorporate the following practices outlined by Becker and Riel (1999) in their description of constructivist teaching:

1) designing activities around teacher and student interests rather than in response to an externally mandated curriculum
2) having students engage in collaborative group projects in which skills are taught and practiced in context rather than sequentially

3) focusing instruction (and assessment) on students' understanding of complex ideas rather than on definitions and facts
4) teaching students to self-consciously assess their own understanding
5) engaging in learning in front of students, rather than presenting oneself as fully knowledgeable (p. 10).

In general, the teaching and learning practices that occur in constructivist classrooms are considered to be both student-centered and student-directed. That is, while activities and content are designed to engage students in authentic learning contexts (points 1-3 above), students are also encouraged to use self-regulatory learning processes to achieve both greater and deeper learning (points 4-5). These last two points, specifically, are geared toward facilitating students' self-regulation (i.e., the ability and motivation to implement, monitor, and evaluate learning strategies for the purpose of facilitating knowledge growth; Ertmer & Dillon, 1998). As suggested by Becker and Riel (1999), teachers who adhere to a constructivist teaching philosophy are likely to promote these self-regulatory, student-directed practices within student-centered classrooms.

It is unclear whether these descriptions from the literature are consistent with the perceptions and practices of technology-using teachers, specifically those who identify themselves as exemplary users. Becker (1994) classified exemplary users based on standards that "suggest a classroom environment in which computers were both prominent in the experience of students and employed in order that students grow intellectually and not merely develop isolated skills" (p. 294). In the Bank Street study (Hadley & Sheingold, 1993), exemplary practitioners were described as directly addressing curricular goals by:

- having students use a wide variety of software including simulations, programming languages, spreadsheets, database programs, graphing programs, logic and problem-solving programs, writing tools, and electronic bulletin-board communications software
- exploiting intellectual tools for writing, analyzing data, and solving problems.

How well do these conceptions of how teachers should use technology align with the ways in which exemplary teachers actually use technology in their classrooms? L. Williams (personal

communication, February 1, 1999) noted that there is an "enormous chasm between conversations occurring in higher education and practices in schools--even in exemplary cases." If this is really the case, it may be important to discern the extent to which practitioners' views and practices differ from those being described by researchers and university educators.

When practitioners (e.g., technology coordinators, teachers) are asked to identify exemplary technology-using teachers or to describe exemplary classroom practices, their responses suggest that they do not necessarily use the same criteria as those used in the best practice literature. For example, when teachers in the Berg et al. (1998) study rated their most important uses of technology, they "agreed that research, writing, and uses related to their own instructional planning were among the most important uses for technology in the classroom" (p. 116). Yet, these activities don't necessarily support the kind of high-level uses advocated in the literature. In fact, the authors noted that "less frequent in use, despite shared belief in importance by coordinators and teachers in this study, were Internet applications, problem-solving, basic-skills practice, and student use of multimedia authoring programs" (p. 119). Interestingly, three of these four applications represent practices that are more likely to occur within constructivist classroom environments. The results of the Berg et al. study suggest that although exemplary practitioners believe that these types of uses are important, they do not consistently, or frequently, incorporate them into their own practice.

There is some indication that technology-using teachers will, given enough time, evolve into constructivist teachers (Fisher, Dwyer, & Yocam, 1996; Hadley & Sheingold, 1993; Sandholtz, Ringstaff, & Dwyer, 1997). The assumption is that technology use actually prompts teachers to change their practices in the direction of more student-centered approaches. Dexter et al. (1999) noted that if this were true then, "This makes the issue one of time. That is, given enough time, the variety of approaches to using technology will homogenize into a constructivist approach" (p. 222).

Yet, Miller and Olson (1994) and others (Hativa & Lesgold, 1996; Kerr, 1996) disagreed with this viewpoint, suggesting that traditional teachers do not become constructivist just because they have new tools at their fingertips. Pedagogical beliefs go deeper than technological capability or accessibility; beliefs define how teachers teach both with and without technology. Furthermore,

changing these beliefs is neither quickly nor easily accomplished (Cuban, 1993; Ertmer, 1999; Ertmer & Hruskocy, 1999; Kerr, 1996). As noted by the President's Panel on Educational Technology (1997):

> In order to optimally cultivate this ground, schools will need to make changes that extend far beyond the mere installation of a network of computers. While some benefits may be obtained by using information technologies to pursue existing curricular objectives or by adding new material to an existing course, the richest harvest is likely to accrue from a fundamental restructuring--at least at the level of the individual course, and ideally, across boundaries. Such fundamental restructuring, however, is likely to prove complex, difficult, expensive, and time-consuming, and may encounter resistance from parents, educators, and the general public, particularly to the extent that such changes conflict with commonly held beliefs about the nature of knowledge and learning (pp. 35-36).

Is it realistic to expect teachers to use technology in the ways currently being advocated by best practice? Given that teachers, themselves, have not yet reached consensus on whether a traditional or constructivist teaching model is "best" (Center for Research on Information Technology and Organizations, 1999), is it reasonable to expect that exemplary users of technology, will, by definition, all adhere to a constructivist philosophy? Furthermore, will they perceive that this approach, is indeed, exemplary?

Purpose

This exploratory study was designed to examine the pedagogical beliefs and classroom practices of a group of technology-using teachers who considered themselves to be exemplary users. Through this research we hoped to identify the beliefs and practices that were common, as well as those that were distinct, across teachers and then to compare our findings to best practice, as described in the literature. Specifically we asked:

1) To what extent do the characteristics of teachers who perceive themselves to be exemplary technology-users compare to characteristics of exemplary users described in the literature?

2) How do teachers define exemplary technology practice? What are their visions of exemplary use and how are these visions translated into practice? What role has technology has played in either enabling or changing teachers' beliefs and practices?

3) How do teachers' perceptions and implementation of exemplary technology practice compare to best practice? To what extent are teachers enacting both student-centered and student-directed curricula?

Methods

Overview

We used a qualitative case-study design to examine teachers' perceptions of their own exemplary technology practice, including the pedagogical beliefs that supported classroom practice. Through a series of written responses, telephone and e-mail conversations, and extended face-to-face interviews and classroom observations, we examined how teachers defined and implemented exemplary practice in their classrooms. Following this, we considered the extent to which teachers' beliefs and practices aligned with the constructivist pedagogy advocated by current educators.

Background

This research was conducted in conjunction with the development of VisionQuest©, a CD-ROM teacher development tool designed to highlight the classroom practices and pedagogical beliefs of exemplary technology-using teachers (Ertmer, Gopalakrishnan, & Ross, 2000). Teachers who wished to be considered for inclusion on the CD-ROM were required to complete an "Application Form for Identifying Exemplary Technology-Using Teachers" (see Appendix). Teachers used this form to describe classroom technology resources, to enumerate their professional and instructional uses of technology, to characterize a successful use of technology in their classrooms, and to share their visions of a "wholly integrated classroom." The application form allowed participants to apply their own definitions of the term "exemplary." This enabled us to examine teachers' individual perceptions of exemplary technology classroom practice, to compare perceptions across teachers, and to examine how these perceptions corresponded to best practice, as outlined in the literature.

Role of the Researchers

The research team consisted of a faculty member and seven students enrolled in an advanced educational technology research course at a large Midwestern university. Students had varied background experiences, in both corporate and k-12 classrooms, and were seeking either masters (n=3) or doctoral degrees (n=4) in the field of educational technology. This study resulted from the need to select, from a pool of 22 applicants, six technology-using teachers to be featured on the CD-ROM being designed to depict exemplary use. As the first step in the CD-ROM development process, the instructor and students collaboratively examined the beliefs and practices of the 22 teachers who, by virtue of their applications to the project, comprised our purposeful sample. Graduate researchers participated in all aspects of the selection process--examining application forms, interviewing teachers, and conducting on-site classroom observations.

Selection and Description of Participants

We initiated the participant selection process by soliciting nominations of exemplary technology-using teachers from 358 (public and private) school principals located within an hour's driving distance of the university. Principals were asked to present the solicitation letter, a description of the CD-ROM project, and an accompanying application form to teachers in their buildings who might be considered appropriate for inclusion on the CD-ROM. Twenty-two teachers, representing 17 different classrooms (8 teachers constituted 3 teacher-teams), completed the application form in which they described their beliefs and practices regarding classroom technology use. In addition, an informed consent form was signed by each of the 22 teachers. Seventeen teachers were available for in-depth interviews and classroom observations during the fall semester (including all 3 teams). Teachers who were interviewed represented a range of subject areas, classroom contexts, and levels of access to technology (see Table 2) and were not considered to be significantly different from those who were not interviewed. Thus, the beliefs and practices of these 17 teachers were thought to provide a reasonable representation of the beliefs and practices of the sample of teachers who applied for the project.

Our interview sample included teachers from two high schools (grades 9-12), one 6th-12th cross-age school, five middle schools (grades 6-8), one preK-8, and six elementary schools (grades 1-5).

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Five of the 17 teachers taught at private schools. The high school teachers (a 3-teacher team and a single teacher) taught science, four middle school teachers (a 3-teacher team and a single teacher) taught music, and 3 teachers (one elementary, one middle school, one preK-8) taught computer skills in a lab setting. The remaining teachers taught in self-contained elementary or cross-age (6th-12th grade) classrooms. Classroom technology resources ranged from student/computer ratios of 1:1 to 12:1. The majority of each school's population was white; ethnic minority students accounted for 0% to 45% of each school's enrollment (see Table 2).

Data Collection

Teachers' applications to the VisionQuest© project comprised our initial data set (see Appendix). As noted earlier, 22 teachers (8 male, 12 female) completed the application form in which they described their instructional and professional uses of technology, their visions for an integrated classroom, and examples of successful uses of technology in their classrooms. In respect to this last item, teachers were asked specifically "to include information about the roles you, your students, and the technology played, how students were grouped, the goal of the activity, its relevance to the curriculum, and the manner in which you assessed outcomes." By considering "successful use" from the teachers' point of view, we hoped to gain valuable insights into teachers' definitions of exemplary use, as well as the kind of technology visions toward which they were oriented. Furthermore, the specific information that teachers included in their successful examples helped us identify the extent to which their practice incorporated the characteristics of an integrated classroom environment described in the literature and outlined in Table 1 (Grabe & Grabe, 1996).

Based on teacher and researcher availability, 17 teachers were interviewed and observed in their classrooms during the 1998 fall semester. Eight teachers were interviewed two times; nine teachers were interviewed one time. Scheduling constraints limited observations of four teachers to one time each; all other interviewed teachers were observed two or more times. Observations were conducted over a one or two hour time period; interviews lasted approximately an hour. Interview questions were structured, primarily, to obtain more detail about teachers' educational and technology

backgrounds as well as their visions for future use. Specifically, we asked teachers to describe their personal journeys of technology integration—how they got started, the obstacles they encountered, as well as their reasons for persisting. Through subsequent classroom observations we witnessed the manner, as well as the extent, to which teachers' visions were translated into practice. Field notes were taken during each observation; interviews were audiotaped and transcribed.

Data Analysis

Early analyses examined the presence or absence of participant and classroom characteristics commonly thought to relate to teachers' exemplary technology use (e.g., years of teaching, technology training experiences, access to resources). Following this, open-ended questionnaire, interview, and observation data were analyzed and coded using both within- and cross-case analyses (Patton, 1990). We began by searching for recurring words and themes that captured each teacher's beliefs about classroom practice and, more specifically, their technology use relevant to that practice. For example, we examined teachers' descriptions of the connections they promoted between students' technology use and the classroom curricula. Did technology serve to supplement, enhance, or transform current curricula? In addition, we examined teachers' visions to determine the extent to which they emphasized students' attainment of basic skills, content, or process (higher-level thinking) skills.

Using the categories outlined in Table 1, we created profiles of each teacher as a technology-using teacher. Following this, we used cross-case analyses to compare teacher profiles, identifying both common and unique patterns of beliefs and practices related to technology use. Secondary data obtained through telephone and e-mail conversations, and teacher and student artifacts (lesson plans, technology projects) were used to support or negate tentative themes, or profiles, that emerged in early analysis stages. For example, whereas Table 1 depicted only two points along a teaching continuum (traditional vs. integrated practice), we found, as might be expected, that teachers rarely used teaching practices that fell solely into one category. Thus, it became necessary to expand the table to include a 'mixed-model' (somewhere between the two ends) that captured teachers' hybrid approaches. As an example, teachers' assessment practices were examined to determine the extent

to which they emphasized facts or skills in isolation (traditional), facts or skills within specific content areas (hybrid), or the application of facts and skills within the context of authentic project-based work (integrated). The results of these analyses, then, provided the bases for our comparison to best practice and allowed us to consider the extent to which teachers' perceptions of exemplary technology practice aligned with criteria used in the literature.

Issues of Validity and Reliability

Three data sources—applications, interviews, and observations—were used to triangulate findings and thus increase reliability. Reliability was also increased through the use of consistent data collection methods. Interviews and observations were both conducted using semi-structured guides developed by the researchers. Themes noted across data sources were discussed and compared in classroom discussions and further validated through co-researcher visits to multiple classrooms. In most cases, either the instructor, a co-researcher, or both, paid follow-up visits to classrooms assigned to individual student researchers. This allowed for multiple, independent observations. In addition, teachers' applications were used to confirm or disconfirm themes noted across interview transcripts and observations.

Interpretation of Results

In this section we present findings that highlight the variety of situations in which teachers achieve technology integration as well as the range of visions and beliefs that support teachers' efforts to achieve exemplary use. Although high levels of confidence and innovativeness were common among all participants, other characteristics, including teachers' visions, beliefs, and practices showed as much variety as they did similarity when translated into classroom practice.

Comparison of Participant Characteristics to Literature-Reported Characteristics

Teaching and technology experiences. According to Becker (1994), exemplary technology-using teachers tend to have both extensive teaching and computer training experiences. In this study, exemplary teachers had from 3 - 30 years of teaching experience, with an average of 13 years. Whereas Hadley and Sheingold (1993) reported that 75% of their sample had 13 or more years of experience, 59% of the teachers in this study (n = 10) had fewer than 13 years, with 6 teachers

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having 6 years or fewer. Becker also noted that exemplary technology-using teachers tend to have accumulated significantly more credits and degrees than other computer users (50-75% of exemplary users compared to 10% of other users). In this study, only six of the 17 teachers (35%) had earned master's degrees. Three teachers had computer endorsements [as part of their bachelors (n=2) or masters (n=1) degree programs]; two additional teachers were in the process of obtaining endorsements.

In general, the exemplary teachers in this study were relatively less experienced than those described by Becker (1994) and Hadley and Sheingold (1993). This difference may reflect recent changes in teacher training programs that now incorporate an increased emphasis on technology training. Perhaps newer teachers are entering the workforce having already achieved high levels of competency. However, a recent report by the Department of Education (1999) discounts this idea, noting that "relatively few teachers (20%) report feeling well prepared to integrate technology into classroom instruction." Still, new teachers are more likely to have mastered basic computer skills before entering the classroom, a pattern that would not have been prevalent when Hadley and Sheingold completed their study. Perhaps just having these basic skills gives new teachers a jumpstart compared to their more experienced colleagues who have had to acquire technology skills on their own time.

Levels of confidence and innovativeness. Another characteristic of exemplary technology-using teachers, noted in the literature (Marcinkiewicz, 1993-1994), relates to teachers' levels of confidence and innovativeness. All of the teachers in this study expressed high levels of confidence for what they and their students were doing with technology. Given that the teachers volunteered to participate in this project, it is fairly safe to assume that they felt confident that their technology practices were, indeed, exemplary. Teachers' confidence was also manifest in their no-nonsense approach to common integration barriers. None of the teachers in this study appeared deterred by lack of resources, knowledge, or time; they found or invented ways to obtain needed resources. It wasn't that the teachers didn't encounter barriers, they did; yet they all managed to work around constraints that have typically halted others' efforts (Ertmer, 1999; Ertmer & Hruskocy, 1999).

Within the context of their teaching practices, all of these teachers had initiated and sustained innovative approaches to teaching. Our participants were considered innovative by their building principals and often by their peers as well (i.e., many had received prestigious teaching awards). Clearly, all of these teachers had taken risks and sacrificed personal time and energy to achieve current levels of technology integration. Yet, "innovativeness," like "exemplary use," is a slippery construct that tends to be defined in relative terms. Compared to their immediate peers, all of our teachers had achieved innovative technology practice, yet compared to best practice, a number of discrepancies were noted. We revisit this point later when we address our third research question.

Support and resource availability. Becker's (1994) study suggested that exemplary technology-using teachers work in school districts that have made large investments in staff development and on-site support. This was confirmed by the majority of participants in our study. All but two of the teachers interviewed noted that they had many opportunities to participate in professional development experiences, including computer training experiences. Yet, similar to results reported by Hadley and Sheingold (1993), almost all of our participants had achieved their technical skills on their own by accessing a wide range of available resources, including, but not limited to professional development opportunities. For the most part, these teachers were responsible for providing rather than receiving training, presenting at various technology conferences, and conducting workshops for other in-service teachers. Teachers in this study (n=10) perceived that they had helped create collaborative working environments, specifically related to technology integration, within their schools. Furthermore, they noted that they had brought colleagues on-board by providing training, collaboration, and ongoing emotional support. For example, Annie, a relatively new teacher, described how team-teaching helped her overcome her fears of technology:

> I have just generally been fearful of technology, because I didn't grow up with it like many of our students have. And so I have had to get over that hump of not really knowing how to use a computer. Teaching with Sam, team teaching - he knows a lot about it so that's really helped me learn. It's a lot easier than I thought it would be.

To achieve technology integration, teachers also need a considerable amount of technical support (Becker, 1994). This includes on-the-spot troubleshooting assistance as well as ongoing system maintenance. Most of the teachers in our study (n = 12) had technology support staff available on-site, while some (n = 4) received additional district-level support. Three teachers received assistance at the district level only. Troubleshooting was completed primarily by the teachers themselves; many also helped with systems maintenance.

The literature suggests (Hoffman, 1996; Means & Olson, 1997) that access to computers, in terms of both location and number, is a major determinant of teachers' success in integrating technology into instruction. Yet some of the teachers in this study were successful with fairly limited resources. Although five teachers taught in classrooms or computer labs with a 1:1 student-computer ratio, the others had student-computer ratios that ranged anywhere from 3:1 to 12:1 (see Table 2). Teachers got around this resource barrier by using effective organization and management strategies. For example, Joan and Jessie used a station approach in which students rotated through various activities; the computer station was just one of many possibilities. Sam's students self-determined when to complete activities; not all of them completed computer activities at the same time.

Teachers' Visions of Exemplary Technology Practice

When asked to describe their visions of technology integration, teachers emphasized a variety of teaching and learning goals. Whereas some teachers emphasized important computer or information literacy skills that their students needed to know (e.g., how to use a spreadsheet), others focused on helping students learn specific content (e.g., the variety of species populating the world), while still others went beyond content to support students' development of problem-solving and critical thinking skills (e.g., using a spreadsheet to predict changing relationships among existing populations and available resources).

Skill-Oriented Visions

Teachers were classified as having skill-oriented visions if they made explicit reference to helping students learn specific technology or information literacy skills. For example, Teresa, a computer lab teacher at a private pre-K-8 school, stressed: "Technology has a goal in and of itself."

Eleven of our 17 teachers noted that students needed to learn basic technology skills; three of these emphasized skills as their primary focus. Yet, all of these teachers made comments that suggested an additional focus on content and/or problem-solving skills.

Content-Oriented Visions

Teachers were classified as having content-oriented visions if they described how technology related to their current curricula. For example, Joe, a middle-school music teacher, stated, "We have a body of knowledge to teach. How we do that is sometimes determined by the tools we have." Beth Ann noted, "Content is where it's at!"

All of the teachers in this study described how technology supported content-oriented goals; nine teachers suggested that content was their primary focus. Among these nine, differences were noted in whether teachers used technology to maintain or go beyond current curricula. Joan's definition of technology integration illustrates the former approach: "Technology integration is looking at technology as if it is not separate. It's not an extra or an add on. It is part of what you do every day, it's using technology as a tool to enhance what you are already doing." In contrast, Bev, a middle school music teacher, described going beyond what was previously possible: "I have become a better teacher, because of technology. . . because the kids own it (the music). It is not me teaching them; it is me giving them opportunities to expand." In this study, 12 teachers used technology to support or enhance current curricula whereas five teachers used technology to go beyond, or transform, current classroom work.

Process-Oriented Visions

Teachers were classified as having process-oriented visions if they emphasized helping students gain higher-level thinking skills such as problem-solving, critical thinking, or lifelong learning skills. Thirteen of our 17 teachers made at least some reference to process-oriented visions; five teachers embraced this as their primary focus. Sam, a high school biology teacher, described his vision of helping students become active, independent learners.

> The least important of our goals is that they learn biology. We are really much more concerned that they become independent learners and critical thinkers. And the independent

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> learning happens only if you give them control. . . . Most people become terribly motivated when they have the control. And we want them to be self-learners; we want them to be critical thinkers.
>
> These kids need to be critical thinkers. They need to distinguish that all information is not equal. And they need to be able to evaluate the likelihood that it is good information. So those are our two primary goals. If they learn some biology along the way, then that's fine.

Overlapping Orientations

Eight teachers described visions that included references to all three orientations—skill, content, and process. This may simply reflect the fact that teachers adapt orientations to meet the needs of multiple stakeholders, or perhaps that visions are implemented in dynamic ways, reflecting immediate needs as well as future goals. Another explanation is that teachers are still evolving in their uses of technology or, more fundamentally, their beliefs about classroom practice. Melissa, a relatively new 2nd grade teacher, emphasized both technology and problem-solving skills within the designated curricular content. She described how she was moving away from her earlier emphasis on isolated skills:

> I was reading an article about math and how our students are taught things but don't understand why they're doing them. And how they lack problem-solving skills and how that's why we're getting behind in science and math. And that made me realize, "Am I doing that? Am I holding my students back by giving them--giving, giving, giving?"

As a result of reflecting on this dilemma, Melissa began to encourage more decision-making in her classroom and to place a stronger emphasis on cooperative learning activities. Furthermore, every group activity was followed by a debriefing session in which students reflected on what they had learned, as well as how they had learned it. By embedding both technology and process-oriented skills into the mandated 2nd grade curricular content, Melissa implemented a vision that integrated all three orientations.

In at least one case, a teacher's practice appeared constrained by existing job responsibilities. Emilie described a vision of technology integration that "provided students with opportunities to see

the connections among subject areas." Yet, in her position as the computer lab teacher, her primary responsibility was to ensure "that middle school students are taught the various technology skills that are necessary for them to be successful in the Information Age." Given this particular context, it was difficult, although not impossible, for Emilie to achieve her expressed vision of integrated technology use.

Technology: Enabler or Change Agent?

Becker and Riel (1999) noted that "how teachers organize their classes to a large extent reflects their beliefs about good teaching" (p. 10). Similarly, teachers visions for, and uses of, technology reflect these same beliefs. In at least two cases, teachers described how technology enabled them to achieve long-held visions of good teaching. Sam explained:

> I have always been devoted to the notion of - you have to be active to learn... Computer technology has simply allowed me to pursue that more. I can spend more time with students because of computer technology. It has liberated me from having to do the lecture. It hasn't really changed my philosophy it's enabled my philosophy; it's allowed me to live the philosophy that I have had for a long, long time.

Bev made a similar point:

> I think my philosophy has always been the same--a real kinesthetic type learning situation—I teach children, I do not teach music. I teach children through music, through technology, through whatever I am doing.

In other cases, technology appeared to provide the impetus to make important changes in beliefs and practices. Joan described this process:

> When I came in, I had not thought about how technology would be integrated into a classroom...I was thinking of technology for me - what I would do; what activity sheets I would create, not what the kids would do. So, as I started using it more I began to say, "OK, the student needs to be the worker a lot more than I do... It became a much more student-centered ...

Thus, in this study, we have evidence supporting two opposing views about the role technology may play in reforming teachers' practices. Sam and Bev provide additional evidence that technology enables an existing constructivist philosophy to be translated into practice. However, Joan 's story suggests that the use of technology can prompt the emergence of more constructivist practices. Our results suggest that although constructivist practices do not depend on the use of technology, technology may both support and facilitate these practices.

Relationship of Teachers' Practice to Best Practice

To answer our third research question, we examined the extent to which the teaching practices of our participants were both student-centered and student-directed, as suggested by the best practice literature (Becker & Riel, 1999). In this section, we describe how our teachers designed, implemented, and evaluated technology-based classroom activities, as well as the extent to which they promoted students' use of self-regulatory learning strategies.

Student-Centered Curricula

Externally mandated vs. participant driven curricula. Becker and Riel (1999) noted that teachers who implement constructivist practices tend to "design activities around teacher and student interests rather than in response to an externally mandated curriculum" (p. 9). We examined our data to compare our teachers' approaches to recommended practice. In general, the teachers in this study implemented a "hybrid" approach to classroom curricula. Although only four of our teachers specifically mentioned using national or state (externally mandated) standards to guide their choice of content and activities, all but one of the teachers described how they used technology to support the "needs of the curriculum." The one teacher (a computer lab teacher) who did not make a strong connection to subject area content focused instead on the specific "goals of technology." Still, this reflects her particular curriculum (technology) as well as the context in which she worked (computer lab).

Having ties to externally mandated curriculum, however, did not mean that teachers ignored or minimized students' interests. On the contrary, the teachers in this study used technology to both increase and sustain students' interest in learning, in general, and in the content areas, specifically.

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As Joe, a music teacher, noted: "I think on the whole, because it is much more relevant (it is done in the tools and language of kids today), it becomes more meaningful for them . . . kids leave with a much better grasp of what was covered."

Teachers tended to embed multiple opportunities for student choice within their curricula. For example, Kate let her students choose which of the 50 states they would report on and which of several topics to include, but they all created a HyperStudio report and they all included four out of eight components. Vivian used technology to make lessons more dynamic by actively engaging students in concepts they were expected to learn at that grade level. She stated, "Technology is just another tool to make your lesson better. The activity (publishing a web page) gives students a reason to research, study, and write." In summary, teachers in this study helped students achieve recommended standards by creating student-centered activities, facilitated through the use of technology.

Teaching isolated facts vs. embedding complex ideas within authentic contexts. Becker and Riel (1999) suggested that teachers who use constructivist-compatible activities tend to engage students in collaborative group projects in which skills are taught and practiced in context, rather than sequentially. As a result, instruction is focused on helping students understand complex ideas rather than remembering isolated definitions and facts. In general, the teachers in this study tended to embed technology skills within other curricular content. Emilie, a middle school computer lab teacher, stated, "Technology skills are taught within content areas so that they are meaningful." Yet, it is not clear whether content area skills were, themselves, embedded within authentic project-based activities. For example, Melissa taught her first graders how to cut and paste (a technology skill) as part of a lesson on contractions (a language arts skill). However, the contraction lesson appeared to be an isolated, skill-building lesson rather than one related to specific projects the students were completing. Whereas 16 of our teachers seemed relatively adept at embedding technology skills within current curricular activities, a relatively fewer number (n = 9) embedded content skills within authentic project-based work on an ongoing basis.

Still, almost all of the teachers in this study had successfully implemented activities that engaged their students in authentic, project-based work. For example, Lindsey described how her fourth grade class created and marketed a music CD of Christmas songs, enabling them to experience, first-hand, a variety of economic principles. Emilie teamed up with a science teacher to engage seventh grade students in an archeological dig in which they learned about the relationships among different Native American cultures, their artifacts, and their environments. Yet, these types of projects were only part of the work that students completed. Students also completed worksheets, practiced skills, and learned facts as part of their ongoing classroom activities.

The fact that these teachers stressed both complex ideas and isolated facts suggests that using constructivist-compatible activities doesn't preclude teachers from using more traditional activities to meet other learning needs. Teachers may enjoy and even prefer using constructivist approaches, but a sole focus on this approach may, itself, be too limiting given the amount of time needed to complete such activities relative to the total number of curricular requirements. Teachers may feel compelled to combine approaches (use a hybrid approach) in an attempt to meet a wide range of perceived needs.

Traditional vs. alternative assessment methods. Exemplary use of technology did not necessarily translate into innovative assessment practices for the teachers in our study. Furthermore, teachers' orientations did not consistently relate to the types of measures used. That is, skill-oriented teachers did not always use objective-type tests and process-oriented teachers did not always use project-based assessment measures. Assessment methods related to teachers' instructional styles as well as their specific goals for students' technology use. Teachers tended to combine a variety of methods including traditional tests, performance-based measures, worksheets, project-based activities, and oral tests.

For example, Emilie's sixth grade class practiced keyboarding skills using a computer typing program. Students were assessed in terms of both speed and accuracy (performance-based assessment) and their names added to a keyboarding stars chart when a specified level of mastery was achieved. In contrast, Emilie's seventh grade class created websites about Native American cultures

after researching and gathering relevant information. Technical skills (creating web pages) were learned within the social studies content areas. Student projects were evaluated by both peers and teacher for their thoroughness in content and the technical features incorporated (project-based assessment).

Student-Directed Curricula

Becker and Riel (1999) noted that constructivist teachers help students assess their own understanding. Furthermore, they described how constructivist teachers model the learning process for their students by "engaging in learning in front of their students" (p. 9). These types of classroom practices are designed, specifically, to promote student attainment of two of the three main components of the self-regulated learning (SRL) process (i.e., monitoring and evaluating) delineated by Zimmerman (1986) and others (e.g., Ertmer & Newby, 1996), with the remaining component being planning. We examined our data to determine the extent to which teachers in our study promoted students' use of planning, monitoring, and evaluation learning strategies. In addition, we examined relationships among teachers' promotion of these strategies and their specific teaching orientations, described earlier.

Eleven of the 17 teachers in our study promoted at least some student use of SRL strategies within their classrooms (see Table 3, last column) including goal setting, self-paced learning, peer- and self-assessment, as well as journal writing and reflection. Specifically, eight teachers promoted strategies specific to student-directed planning, seven teachers encouraged student monitoring, and eight teachers promoted student self-evaluation. Two teachers employed two of the three types of strategies; five teachers, including the three high school team-teachers, promoted all three.

Sam provides an excellent example of a teacher who helped students become self-directed by facilitating their use of SRL strategies. He explained, "At the beginning of every unit, students ... are setting goals for themselves and then adjusting what they're doing based upon how their performance is going. It gets them actively involved in directing their own course through the unit." Connie, one of Sam's team teachers, explains further:

> We focus very, very heavily on goal setting and on making modifications as you go. If you don't achieve a goal in a particular area, you need to compensate for it somewhere else in the unit. This really allows students to take a look at themselves. If it's your plan, your calendar, you devise all of that yourself--then if it is not working, you are the responsible party.

Students in Sam's classroom were expected to select, implement, and evaluate their own learning activities. Assessments were conducted in a variety of ways, most of which were student-directed. Students self-determined when to take an oral test after completing other unit activities. In addition, students kept research logs and wrote reflections, allowing them to assess weekly progress toward their goals.

In general, teachers who emphasized a process-oriented vision also promoted student self-regulation within their classrooms. Eleven of the 13 teachers who made at least some reference to process-oriented visions promoted students' use of SRL strategies. Furthermore, the five teachers who emphasized process skills as their primary focus also made the greatest use of SRL strategies. Perhaps, SRL strategies were simply the tools teachers needed to translate their process-oriented visions into classroom practice. In general, teachers who focused on content (n = 9) used a mixture of student-directed and teacher-directed strategies, whereas teachers who focused on skills (n = 3) used more teacher-directed strategies.

These patterns of strategy use, as they relate to teachers' visions, may be partially explained by the grade level at which teachers worked. That is, teachers at higher levels of schooling may be in better position to promote student-directed strategies. In this study, teachers with skill orientations, who primarily utilized teacher-directed strategies, all taught at the elementary level. Teachers at this level may feel obligated to help students learn basic skills, moreso than at the upper levels. In addition, students may not be intellectually or emotionally ready to assume control for their own learning processes during the early grades.

Summary

In general, the teaching practices and beliefs of the exemplary teachers in this study were both student-centered and student-directed. Yet, in relationship to best practice, they might best be

described as hybrid approaches. For example, teachers in this study implemented externally mandated curricula, yet used technology to do so in student-centered ways. Learning activities and assessment measures varied from activity to activity. Although many of our teachers emphasized learning skills in context, many of these same teachers required students to learn facts and skills, sometimes in isolation. Finally, although teachers with process orientations tended to foster self-regulated learning in their students, teachers with skill or content orientations implemented fewer strategies to promote these practices. The results of this study suggest that exemplary technology use, as perceived and practiced by teachers, does not readily align with current descriptions of best practice, but rather appears to exemplify what happens when visions meet reality in today's k-12 classrooms.

Discussion

Although it is generally agreed that teachers can be exemplary constructivist teachers without the use of technology, current sentiment suggests that exemplary technology-users only operate within a constructivist framework. As expected, teachers in this study, perceived to be exemplary users, were at many points along the instruction-construction continuum. This suggests that definitions of exemplary, held by teachers themselves, are not necessarily based on definitions provided in the literature, but rather on the very real and practical world in which they implement their practice. Exemplary technology practice looks and acts differently depending on a host of variables including the grade level at which teachers work, the visions which they embrace, the relative use of technology by others around them, as well as the very real constraints under which they attempt to implement their visions, in terms of both curricular expectations and available resources. Perhaps, given a perfect world, these teachers would implement practices that aligned more closely with those described by Becker and Riel (1999). Yet given current classrooms, students, resources, and curricular expectations, they have achieved a more reasonable and workable "best."

All of the teachers in this study were exemplary in one form or another. They were all motivated, energetic, and dedicated teachers who had gone beyond usual responsibilities to design activities that engaged students in meaningful technology use. In many cases, they had overcome

both access and technical support limitations to achieve these goals. Although the majority of teachers in this study (65%) described visions that included pedagogical elements that supported a constructivist philosophy, only five teachers implemented those visions in alignment with best practice. This is similar to the finding by Berg et al. (1999) in which teachers reported wanting to incorporate higher level uses, but not currently being able to do so. Given that visions typically precede practice, it's possible that these teachers will, in time, translate more of their ideas into practice. Perhaps these teachers (and others) would benefit from seeing how colleagues have implemented their student-centered and student-directed visions within realistic environments. Knowing how others have eliminated or circumvented barriers may help teachers find reasonable methods for achieving their visions under less-than-optimal conditions.

Although the teachers in this study were similar to those described in other studies of exemplary technology users (Becker, 1994; Hadley & Sheingold, 1993), there were also a number of differences. Because of our small number of participants we were able to examine and describe teachers' individual situations, as opposed to describing the most common situation. This allowed us to see that, with the exception of high levels of confidence and motivation, no one characteristic or environmental resource appeared to be essential to exemplary use. Our sample included teachers who represented all possible combinations of variables; they were young and old, experienced and new teachers who worked at all levels of schooling (preK-12), in a range of subject areas, and who had variable levels of access to resources and support. However, what was most common across teachers was the belief that technology provided a valuable tool for achieving their visions of teaching and learning (whether they be skill, content, or process-oriented). This finding highlights what many educators have known, but perhaps forgotten in the more recent concern for acquiring resources: high levels of access and support, although desirable, are neither necessary nor sufficient for exemplary technology use to occur. It would be useful if the literature included more examples of teachers who have done meaningful things without having the latest and greatest equipment, since this is more likely to be the situation for the majority of teachers. It is our hope that the examples included here can provide novice users with powerful visions of use as well as practical strategies to achieve them.

Limitations and Directions for Future Research

Besides the small number of participants, additional factors may limit the impact of this study. Due to the nature of the application process and the fact that we focused on classrooms within 60 minutes travel time, our participants all resided within in a fairly small geographical area. Additionally, because our study was conducted within a semester's timeframe, we were unable to observe everyone who applied for the project, or to spend great lengths of time in any one classroom. Finally, as noted previously, there are numerous definitions and interpretations of exemplary technology integration. Perhaps we would have encountered a different population if we had asked principals to recommend exemplary teachers who use technology as opposed to exemplary technology-using teachers. Technology-using teachers tend to be identified relative to what others are doing around them, perhaps placing an unnecessary emphasis on teachers who use technology as opposed to teachers who use it well. It will be important to compare our teachers' visions to those of exemplary teachers who use technology but do not perceive themselves to be exemplary users. Also, given that we examined the visions of a very specific group of teachers, it might be important to determine the extent to which the general population of teachers also embraces these different types of visions. Do technology-using teachers, in general, have a greater or lesser tendency to adopt process-oriented visions? These are questions to be explored in future work.

Conclusion

Based on the results of this study, it appears as though no one technology resource or educational experience is necessary for exemplary technology use to occur. Similarly, no one vision of teaching and learning motivates teachers to strive for exemplary use. Teachers in this study embraced visions that encompassed multiple emphases (skill, content, learning processes) depending on the perceived needs of their students as well as the perceived requirements of their jobs. However, it is probably safe to assume that these teachers are the exception, rather than the rule; they have achieved high levels of confidence related to technology use. Furthermore, they have made classroom technology use a priority because of the value they see for both themselves and their students.

Although being able to integrate technology is fast becoming an expectation for all teachers, it is not clear how this translates into practice. Based on the results of this study, however, it is fairly clear that some discrepancy exists between that which is advocated in the literature regarding technology best practice and that which occurs in schools, even in classrooms perceived to be exemplary. What is less clear, however, are the reasons for these discrepancies. Are teachers still evolving in their constructivist practices, relative to technology use, or are the expectations, outlined in the literature, unrealistic? To what extent can we expect technology best practice to occur in teachers' classrooms? As suggested by McLaughlin (cited in Dexter el al., 1999), best practice may be an unrealistic goal:

> Instruction as observed in a classroom at any point in time reflects a teacher's response to many elements in the school and classroom setting—students, competing demands, instructional goals, norms, and expectations, to highlight just a few. Teaching practice is embedded in . . . the "nowness" of the teaching context (p. 223).

If, however, teachers are still evolving, professional development experiences can be designed to support teacher growth. Perhaps, the description of exemplary practice included in the literature should be broadened to include more examples of how teachers adjust their constructivist practice to reflect real constraints and conflicting needs. It might also be useful to illustrate teachers at different points in their journeys of technology integration -- not to criticize or dismiss those who have not yet achieved exemplary use, but rather to highlight strategies they have used to move forward -- to illustrate the path moreso than the destination. By providing realistic visions of what others have achieved, teachers may be motivated to begin their own journeys toward exemplary technology use. Only by working within teachers' existing situations, can we truly expect best practice to be achieved.

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Table 1 Attributes of Traditional and Integrated Classroom Environments

Categories of Classroom Practice	Traditional Setting	Integrated Setting
Classroom Focus	• Teacher centered (didactic)	• Learner centered (interactive)
Teacher Role	• Present information • Manage classroom	• Guide discovery • Model active learning • Collaborator (sometimes learner)
Student Role	• Store information	• Create knowledge • Collaborator (sometimes expert)
Curricular Characteristics	• Breadth • Fact retention • Fragmented knowledge and disciplinary separation	• Depth • Application of knowledge • Integrated multidisciplinary themes
Classroom Social Organization	• Independent learning • Individual responsibility for entire task	• Collaborative learning • Social distribution of thinking
Assessment Practices	• Fact retention • Product oriented • Traditional tests • Norm referenced	• Applied knowledge • Process oriented • Alternative measures • Criterion referenced
Role for Technology	• Drill and practice • Direct instruction • Programming	• Exploration and knowledge construction • Communication (collaboration, information access, expression)
Technology Content	• Basic computer literacy with higher level skills building on lower level skills	• Emphasis on thinking skills and application

Note: Adapted from Grabe, M., & Grabe, C. (1996)

Table 2 Demographics of Exemplary Technology-Using Teachers (names are pseudonyms)

Name	Years Tchg	School Size	School Location	Ethnic Makeup	Public/ Private	Grade Level	Content Taught	Classroom and Lab Computer Resources	Special Features
Jamie	8	6	mid-size city	0%	private	6-12	All	3 Macs 1 Tosiba 1 Apple IIe	crossed-age students
Melissa	5	917	urban fringe of mid-size city	8.4 %	public	1	All subjects	4 IBMs 1 IBM lab (30 stations)	
Bev	23	800	urban fringe of large city	45%	public	6-8	Music Com Skills	6 Mac G3s 3 Mac labs (26 stations in each)	
Lindsey	5	505	small town	3.8%	public	4th	All subjs	1 Power Mac 1 LCII Mac Library Media Center (34 stations)	

Table 2 (con't)

Name	Years Tchg	School Size	School Location	Ethnic Makeup	Public/ Private	Grade Level	Content Taught	Classroom and Lab Computer Resources	Special Features
Teresa	3	400	urban fringe of large city	DK	private	prek-8	Computers	Computer lab with 26 Pentium stations	school for gifted; primarily white
Vivian	17	527	urban fringe of mid-size city	3.8	public	4th	All Subjs	4 IBMs 1 IBM lab (30 stations)	
Sam Annie Connie	30 6 10	2000	mid-size central city	10%	public	9-12	Biology	15 Mac G3s 2 Power Macs	team taught; block 8 schedule; 45 students/hour
Mary Joe Beth Ann	21 29 14	863	mid-size central city	13.6%	public	6-8	Music	15 Power Macs	team planning

Table 2 (con't)

Name	Years Tchg	School Size	School Location	Ethnic Makeup	Public/ Private	Grade Level	Content Taught	Classroom and Lab Computer Resources	Special Features
Emilie	5	DK	urban fringe of large city		private	6-8	Computers	Computer lab with 17 Power Macs	
Kate	21	DK	urban fringe of large city		private	3K-5	Computers	Computer Lab with 10 iMacs (140 computers in lower school)	
Don	10	395	large city	24.6%	private	9-12	Science; Computers	17 older Pcs 2 Pentium Pcs 1 IBM lab (36 stations)	
Joan Jessie	6 12	600	urban fringe of large city	20%	3.6%	1-2	Science themes	8 Pentiums 2 computer labs; one Mac, one IBM (28 stations in each)	looping; job sharing; sci & tech magnet school

Table 3 Teachers' Visions of Technology Practice and Use of Self-Regulatory Strategies

Teachers' Visions - Primary Orientation				Teacher-Directed vs. Student-Directed Strategy Use		
	Skill	Content	Process	Teacher-Directed	Mix	Student-Directed
Kate	x			P M	M	
Lindsey	x			P M	M	
Teresa	x			P E	M E	
Don		x		P M E	P M E	M
Emilie		x		P M E	P M	E
Joe		x		P	P M	
Joan		x		P	P M E	P E
Jessie B.		x		E	P M E	P E
Mary		x		P M E	P M E	P
Beth Ann		x		P M E	M	
Melissa		x		P M E	P M E	M
Vivian		x		P M E	P M	
Annie			x		E	P M E
Bev			x		P M E	P M E
Connie			x		E	P M E
Jamie			x		M	P M E
Sam			x		M E	P M E

Note: P = Planning strategies; M = Monitoring strategies; E = Evaluation strategies

Appendix:
Application Form for Identifying Exemplary Technology-Using Teachers

Name: _____ School: _____
City: _____
School Phone: _____ Fax: _____ Email: _____
Home Phone: _____
Grade Level: _____ Content Area (if applicable): _____

Please answer the following questions as accurately and honestly as possible. You may use extra paper if you wish to elaborate on any response.

1. Describe your available technology resources.
   (e.g., number/type of computers and peripherals; where located; support personnel)

2. Describe your professional uses of technology (how you use technology outside the classroom).

3. Describe your instructional uses of technology (include names of relevant software).

4. Describe an example of a "successful" use of technology in your classroom. Include information about the *roles* you, your students, and the technology played, how students were *grouped*, the *goal* of the activity, its relevance to the *curriculum*, and the manner in which you *assessed* outcomes.

5. Assuming no constraints, describe your vision of a wholly integrated classroom.

END

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